

May 31, 2018

Dr. Andrew Rawicz  
School of Engineering Science  
Simon Fraser University  
Burnaby, British Columbia  
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**Re: ENSC 405W Project Proposal for NuCare Band**

Dear Dr. Rawicz,

The attached proposal outlines an overview of our prototype, NuCare Band, for our ENSC 405W Capstone project. NuCare Band is aimed to consistently monitor patients' vitals and allow doctors to follow up with their patients. We believe that our medical wearable allows medical professions to reliably process and manage patients' data both more effectively and efficiently. Hence, caregivers can cater prompt and proper care to patients whenever needed.

The purpose of this document is to provide initial stage of designs and its implementation including anticipated risks and benefits associated with the product. Furthermore, it illustrates tentative budget for prototype, followed by current market analysis and competition.

CardioTech Labs is composed of five perseverant engineering students: Younghoon Jee, Carson Lai, Liteng Cheok, Alfonso Diaz, and Qassam Yomok. Every team member is competent and possesses different skill sets from extensive hardware and software experiences gained from industry and school.

Thank you for the time to review our proposal for the NuCare Band. If you have any inquires or concerns regarding our proposal, please contact our Chief Executive Officer, Alfonso Diaz, by email at [adiazalo@sfu.ca](mailto:adiazalo@sfu.ca).

Sincerely,



Alfonso Diaz  
Chief Executive Officer  
CardioTech Labs



CardioTech Labs

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# PROJECT PROPOSAL

## NUCARE BAND

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**Submitted to**

Dr. Andrew Rawicz & Prof. Steve Whitmore  
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**Publish Date**

May 31, 2018



## Executive Summary

While the wearable industry has been booming for the past few years and hospitals becoming more modernized than ever, very few companies are moving towards developing wireless technology for the healthcare sector. CardioTech Labs sees this as an opportunity to directly benefit the healthcare centers such as hospitals and clinics, both public and private, and their patients.

The NuCare Band aims to help hospitals administer prompt and effective care to their patients by providing doctors and nurses with accurate readings of the patients' heart vitals while they are in the hospital, as well as after they are discharged.

The main vital signs monitored by doctors and nurses include: body temperature, pulse rate, respiration rate and blood pressure. Although the last one is not strictly a vital sign, it still provides a good insight of the patient's health. [1] The NuCare Band will be focusing on measuring heart related vital signs including pulse rate, blood pressure and oxygen levels in the blood.

The monitoring information from the patient wearing the NuCare Band will be sent live to the hospital's database, which allows caregiver to access the information at any time. Patients with heart diseases or coming out from a heart surgery would need a wide range of treatments including pills and rehabilitation sessions. Doctors will be able to observe and log the patients' response to treatments and modify those as necessary. Similarly, they could also know when something is wrong and bring the patients immediately back to the hospital.

CardioTech Labs was found to make a difference in the life of the patients, looking forward to not only indirectly allowing them to receive more efficient care, but also drastically improving the quality of service they receive.



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## Glossary

**SpO2:** Blood oxygen saturation level.

**Bradycardia:** Slow heart rate, defined as below 60 bpm.

**Tachycardia:** Fast heart rate, defined as above 100 bpm at rest.

**Firestore:** Realtime Database is a cloud-hosted database. Data is stored as JSON and synchronized in real-time to every connected client.

**IoT:** Internet of Things.

**Diastolic pressure:** Minimum in between two heart beats [2]

**Systolic pressure:** Maximum during one heart beats [2]



# 1. Introduction

Golden hour is a critical period following a traumatic injury during which, if prompt medical treatment is performed, mortality rate would significantly be reduced. [3] According to the research, “The effect of a golden hour policy morbidity and mortality of combat casualties”, it is well established that the likelihood of patient death (case fatality rate) decreases by 6.1% if proper care is provided during golden time. [4]

As provision of immediate care and early diagnosis significantly impacting a patient’s survival rate, medical wearables has become more prevalent in the medical industry. Medical wearables are health monitoring systems. As medical devices become more intelligent with the help of improved technology, the global medical wearable market is significantly growing every year. The wearable market reached over USD \$6.22 billion in 2017 and is forecasted to reach USD 14.41 billion by 2022. [5] In fact, emergence of medical IoT has enabled more impactful care.

CardioTech Labs confidently proposes vital monitoring wearable- NuCare Band. The NuCare Band is a patient monitoring wearable device that can accurately measure a patient’s vital signs such as pulse, oxygen level and blood pressure. It aims to overcome the drawbacks of other devices currently available in the market such as expensive cost, uncomfortable fit, low accuracy and lacking portability. With the patients’ vital data collected, it sends information to a centralized database remotely and securely. So, caregivers can continuously monitor and analyze a patient’s data and can consistently provide quality care. The lightweight medical wearable is expected to enhance patient care and promote better quality of clinical performance.

This proposal outlines a high-level overview of the project, detailed scope of project, and potential risks and benefits associated with the project. Moreover, the paper contains analysis of the current trends and the potential competition in the market. Material cost breakdown will be included in the project budget with possible sources of funding. Lastly, estimated project timeline using Gantt is included to capture the essence of what needs to be done in a timely manner.



## 2. Background

Vital signs are measurements of the most fundamental functions of human body. Based on patients' vital signs, medical professions determine which treatment protocols to follow. Vital signs are essential data to assess acute medical problem. Thus, they serve as a means of quantifying severity of an illness in early stage. Vital signs are primarily composed of four components: body temperature, pulse rate, respiration rate and blood pressure. [1] NuCare band is designed to detect essential biological parameters such as pulse rate, blood pressure and oxygen level in regulated manner.

As technology advances, medical devices become much smarter. However, current medical wearable devices in the market lack some critical features that hinder medial wearables from seamlessly integrating into healthcare system. Main drawbacks are lack of portability and workflow integration, and expensive cost. So, our team has designed NuCare Band that solve dilemmas addressed in current medical wearable market. CardioTech Labs focuses on four key attributes when designing NuCare Band: accuracy, regulation, integration, and security. [6]

## 3. System Overview

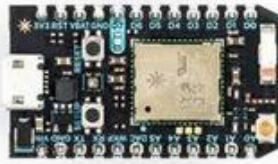
### 3.1 Product Design

NuCare Band is a wearable device designed to allow doctors and clinicians to monitor their patients. The device will keep track of patients' vital signs such as abnormal heart beats, low oxygen levels and high blood pressure. The NuCare Band will alert the patient's doctor after detecting any of these signs. The product is divided into two main components, the hardware and software components.



### 3.1.1 Hardware Components

- *Microcontroller (Particle Photon)*



**Figure 3.1: Particle Photon [7]**

Based on Cypress's WICED architecture, Particle Photon contains a powerful STM32 ARM Cortex M3 microcontroller with Cypress' industry-tested BCM43362 Wi-Fi chip, for this prototype we are using Particle Photon microcontroller with an integrated Wi-Fi chip. However, we will be using Particle Photon with u-blox GSM and LTE modules for our final product. Particle Photon provides a lightweight operating system for embedded IoT devices, this will allow NuCare Band to do real time operations and update the cloud at the same time. Using the Web IDE on the Particle platform we will be able to update the software on all of our devices by a click of a button.

Since NuCare Band is a wearable device, the size of the band is very important in our design. Particle Photon contains a powerful STM32 ARM Cortex M3 with a Wi-Fi chip and the ability to integrate and control multiple sensors at the same time. However, Particle size is small enough to be used inside the NuCare Band. [7]

- *Pulse Sensor*



**Figure 3.2: Pulse Sensor [8]**





Pulse Sensor is used to measure the speed of the heart beats, the sensor we are using records the number of heart beats per minute (bpm). Measuring heart pulse is as simple as holding a finger to your wrist and timing the beats with a watch. This sensor can fit over a fingertip and it is able to transfer the mechanical pulses into electrical signals. The electrical signal will be used by the microcontroller to record and analysis the heart rate and report abnormal behaviors. [8]

- *Blood-Oxygen Sensor*

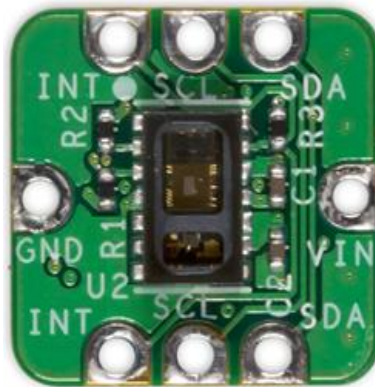


Figure 3.3: Blood-Oxygen Sensor [9]

Blood-Oxygen readings are a clear indication to the percentage of oxygen-saturated hemoglobin relative to total hemoglobin in the blood. A sensor called MAX30102, emits light of two different wavelengths through the skin and blood vessels to determine the SpO2 levels accurately in real time. The sensor will send these readings to the microcontroller, which will process it and send it to the cloud.

- *Blood-Pressure Sensor*

As for the sensor used to measure blood pressure, we are working very closely with a startup company called Valencell to provide us with the required sensor. Since we are looking for a sensor that can be integrated into our band with, no mechanical actions are required to do the measurements.

### 3.1.2. Software Components

- *Particle Server and Database*

Particle Photon microcontrollers are pre-configured to communicate with the device cloud server. The device cloud provides all the required infrastructure to update the NuCare Band

wirelessly. Particle microcontroller collects data from the device sensors and send them to the device cloud through a particle server.

The Particle server will update the SQL database with real-time data after being analyzed and processed by the main software stored in the device cloud.

- *Firestore Database*

To store real-time data as well as historical data, we will use firestore database. Firestore will allow doctors to monitor multiple patients' real-time and historical data at the same time using multiple devices. Firestore will read data from Particle database and store old data in historical records for each patient. Doctors' devices will communicate with firestore database to monitor all of the analyzed data and show any abnormal behaviors.

- *NuCare Software*

NuCare software will be stored in the Particle cloud. The software will analyze all data collected by the NuCare Band and indicate strange behaviors and alert the doctor in case of any threat to the patient life.

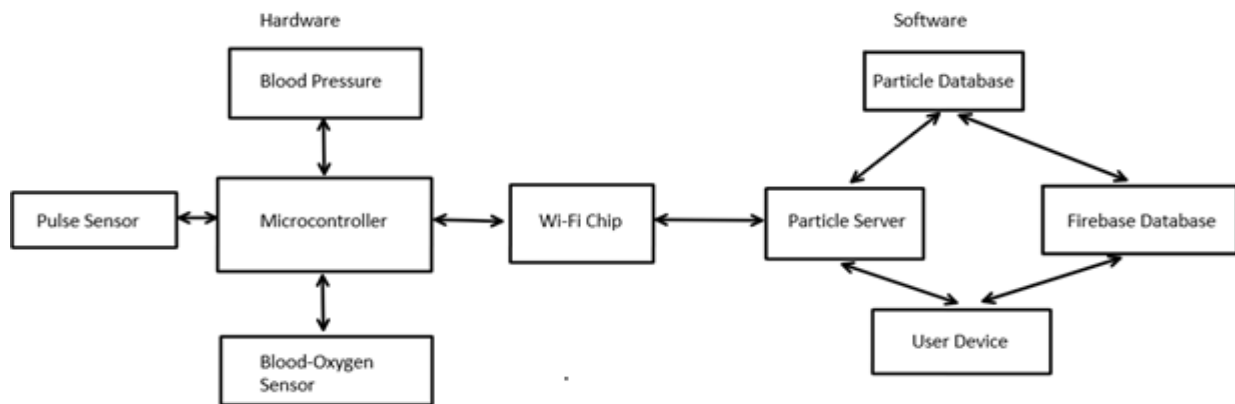


Figure 2.4: Top-level Design



## 3.2 Scope

According to the Centers for Disease Control and Prevention, the leading cause of death was heart diseases and in most of these cases the death was unpredictable. NuCare Band is a wearable, non-invasive device that allows doctors to monitor their patients' vital signs and help them before it's too late.

The device will focus on measuring vital signs such as abnormal heart beats, low oxygen levels and high blood pressure. Heart beats vary from a person to another. However, normal heart rate for a human adult ranges from 60-100 bpm. The device will alert the doctor in case of regular heart beats that are slower than 60 bpm or faster than 100 bpm. Slow heart rate is an indication of a disease called Bradycardia; while a fast heart rate indicates another disease called Tachycardia. The band will also notify the doctor in the case of irregular heart rate. [10]

Blood oxygen level is the amount of oxygen circulating in the blood. Normal blood oxygen level ranges between 75 and 100 mmHg. NuCare Band uses a sensor which emits two different wavelengths of light to indicate the amount of the oxygen in the blood. NuCare Band will alert the doctor if the oxygen level drops below 60 mmHg. Depending on each individual case, the doctor will decide what treatment is best for the patient.

Blood pressure is the pressure exerted by circulating blood cells on the walls of the blood vessels as the heart pumps. Blood pressure is usually expressed in terms of the systolic pressure over diastolic pressure. Normal blood pressure for a human adult is approximately 120/80 mm Hg. In case the blood pressure drops below the normal limit or exceeds the limit, NuCare band will notify the doctor the patient status. [2]

## 3.3 Benefits

NuCare Band contains various benefits in the medical industry as the proposed device aims to provide convenience to both doctors and patients. The current standard of monitoring the majority of patients, involves the measurement of body temperature, pulse rate, blood pressure, blood oxygen saturation and, respiration rate on average of a few hours every day. [11] The proposed device aims to monitor patient's vital signs continuously and having the measured information transferred to the doctors, allowing doctors to be individualize and coordinate care for each of their patients.



Patients are usually connected to leads or cords which usually prevents them from moving comfortably. [11] NuCare Band makes it more convenient for the patient as it allows them to move freely, without any restrictions. Also, Patient care differs depending on their medical condition. Multiple patients are often under the care of one nurse, consequently the management of patient's vital signs is very critical to determine the best possible care for the patient.

A doctor can only address one patient at a time. However, having a device, like NuCare Band which allows patient's vital signs to be monitored continuously will provide a better picture of the patient's condition for the doctor. CardioTech Labs provides the monitoring of vital signs using a wearable device that could transmit information to a cloud. Therefore, Doctors can monitor patients' condition through a cloud, which would benefit the doctor to prioritize their patients according to their medical conditions and needs.

It's critical for hospitals and medical facilities to monitor the patients' recovery condition outside the hospital via remote monitoring. Our proposed device can reduce patients' length of stay in the hospital, as well as lowering the readmission rates after their discharge. As doctors are usually concern over the health of newly released patients, they will be able to track and monitor their patients' condition wirelessly using NuCare Band, regardless of their location. This will also improve hospitals' quality of care overall.

### 3.4 Benefits

Measuring a patient's vital signs in the hospital is essential to clinical assessment and risk evaluation in order to prevent patients' health from deteriorating. Based on a review of 87 different fitness trackers, the accuracy of the devices are a problem. The devices were found to be inaccurate when it is measuring heart rate. Every device tested was off by more than ten beats per minute, which is a lot when it comes to measuring your fitness. [12] Having said that the information gathered through the NuCare Band would be shared with the doctors, this may negatively affect the doctor's analysis of the patient's wellness. This could result in doctors providing inaccurate analysis of the patient. In order to prevent this from happening, multiple sensors should be used to improve the accuracy of the device.

Another potential risk is the failure to transmit data using the Particle Photon. Our proposed design collects large amounts of information every single day. Essentially, all the information is fed into one server. With these collected medical information, NuCare Band can be used to accurately



analyze things, like diagnostic trends and disease outbreaks. Failing to transmit data would result in doctors not being able to keep track of their patients' wellness.

## 4. Market and Competition

### 4.1 Market Analysis

The market segment we are targeting for the NuCare Band is the healthcare systems. Specifically, public-sector hospitals and private-sector clinics in Canada. The purpose of the band is to keep track of patients' heart vital signs inside and outside the hospital and allow doctors and care givers to see the effect of drugs and treatments live and have a record of it.



**Figure 4.1: Connected Health Conference Logo**

At the connected Health Conference held on October of 2017, doctors and industry experts came together and discussed the use of IoT devices, wearables and remote patient monitoring devices in healthcare. Dr. James Mault, Chief Medical Office at Qualcomm Life stressed out the fact that doctors and clinicians

would be much better off having data on the patient once she/he leaves the hospital. As far as the patient's health records goes, once the patient leaves, "it's a black hole" of data. [13]

Other critical factors mentioned during the conference include; the lack accuracy in some wearable devices as well as low percentage of adoption and retention from both the patients and the hospital staff. [13]

CardioTech Labs sees this vacuum in the market place as an opportunity to improve the workflow within the hospitals and clinics and with it improve the care and attention given to patients. With the NuCare Band we aim to give doctors and nurses accurate data to quickly respond to the patients' circumstances inside and outside of the hospital.

### 4.2 Competition

There are no major competitors in the market segment we are aiming at. While there exist multiple fitness trackers in the sale and there is expected to be more in the future [14]; none of those products



are targeted as an aid for doctors and nurses in hospitals or clinics. The most predominant of these devices are shown below.

#### 4.2.1 Embrace - Seizure Detection Wristband



**Figure 4.2: Empatica's Embrace, a seizure detection wristband [15]**

The company Empatica, has developed a device capable of identifying seizures using machine learning and notifying the patient's caregivers. The device, which has been FDA approved, monitors and the sympathetic nervous systems through the skin and analysis the electrothermal activity. [15]

#### 4.2.1 Fever Scout – Continuous body temperature monitoring patch



**Figure 4.3: Fever Scout patch [16]**

The Fever Scout patch is meant to provide a continuous body temperature monitoring and history of the patient. This device which has also been FDA approved, is meant for babies and young children. It is placed under the arm and connect with the doctor's or caregiver smartphone which can be almost 40 meters in range. [16]



## 4.2.2 Fitness Trackers



Figure 4.4: Fitness trackers in the market [17]

Fitness trackers are used very commonly today as a way to monitor activities and health quite accurately. [18] Brands such as Fitbit, Samsung, Moov and many others keep releasing new versions every year. However, the problem with fitness trackers is their lack of accuracy and regulation. It is this reason why they are not introduced in the healthcare system; since their accuracy must be similar to the devices used in the hospital itself. [19]

## 5. Financial Plan

### 5.1 Cost Analysis

Materials	Quantity	Cost (USD – Tax and Shipping)
Particle Proton Chip	1	\$25
Pulse Sensor	1	\$30
MAX30100 Heartbeat Sensor	1	\$10
ICStation Heartbeat Sensor	1	\$5
<b>Contingency Fund</b>	1	\$100
		Total: \$170

Table 5.1: Cost Breakdown



## 5.2 Sources of Funding

In order to fund the NuCare Band, CardioTech Labs. has decided to apply for both the Wighton Engineering Development Fund, and the Engineering Science Student Endowment Fund. These applications will not be available until our final prototype design in ENSC 440 at Simon Fraser University. Therefore, the founding members of CardioTech Labs. will split payment equally until a source of funding is secured. In the case that funding is declined, members of Cardio Tech Labs have agreed to fund the project upwards of \$100 each, giving a grand total of \$500.

# 6. Project Schedule

## 6.1 Gantt Chart

Figure 6.1 shows the Gantt Chart for NuCare Band as well as document deadlines for ENSC 405W. It includes five main categories, consisting of: Project Idea, Documentation/Presentations, Software Development, Hardware Development, and Testing, which are then subcategorized into its appropriate categories. In addition, below in Figure 2.2, it shows the Milestones of NuCare Band and the deadlines that we have set as a company.



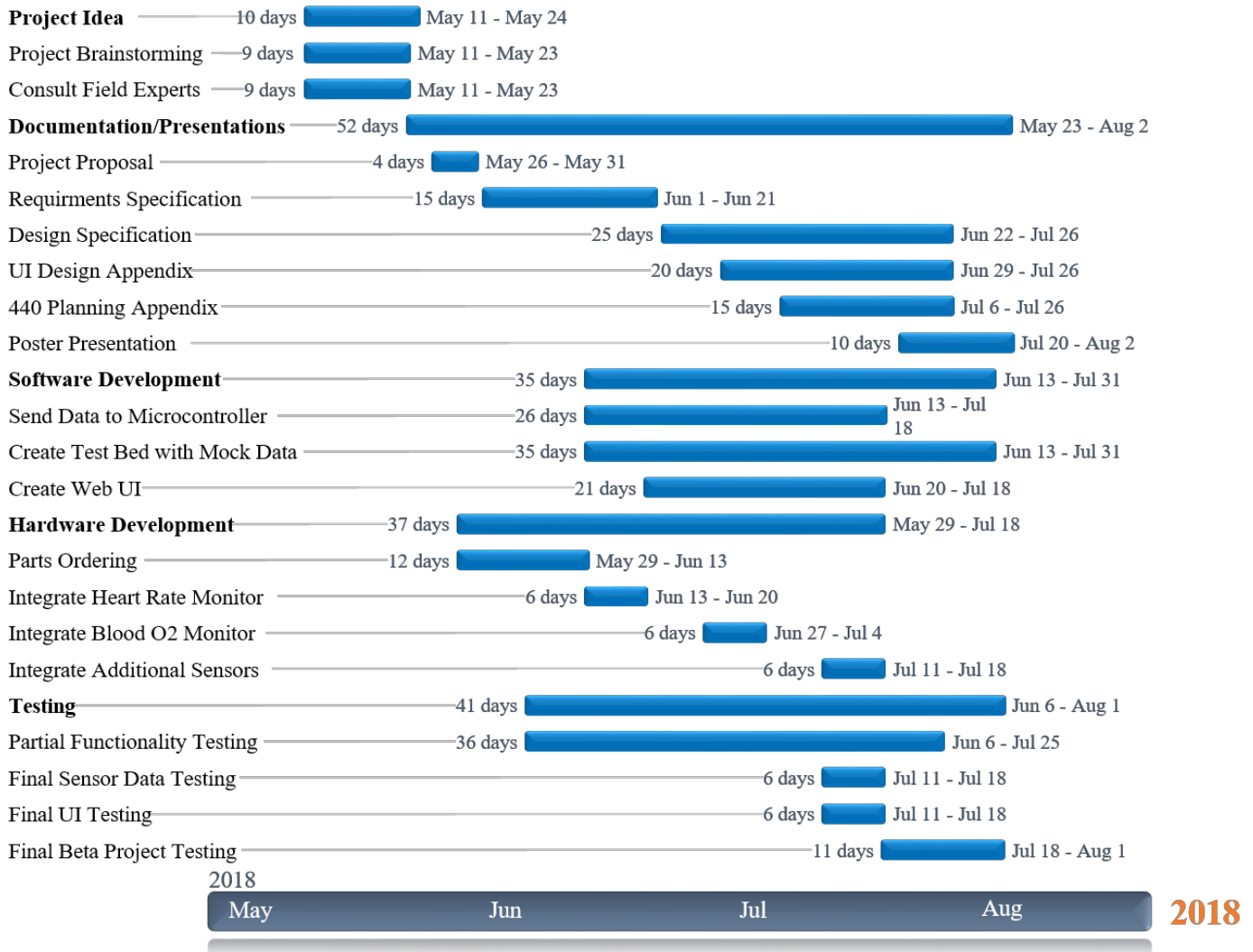


Figure 6.1 - Gantt Chart for NuCare Band

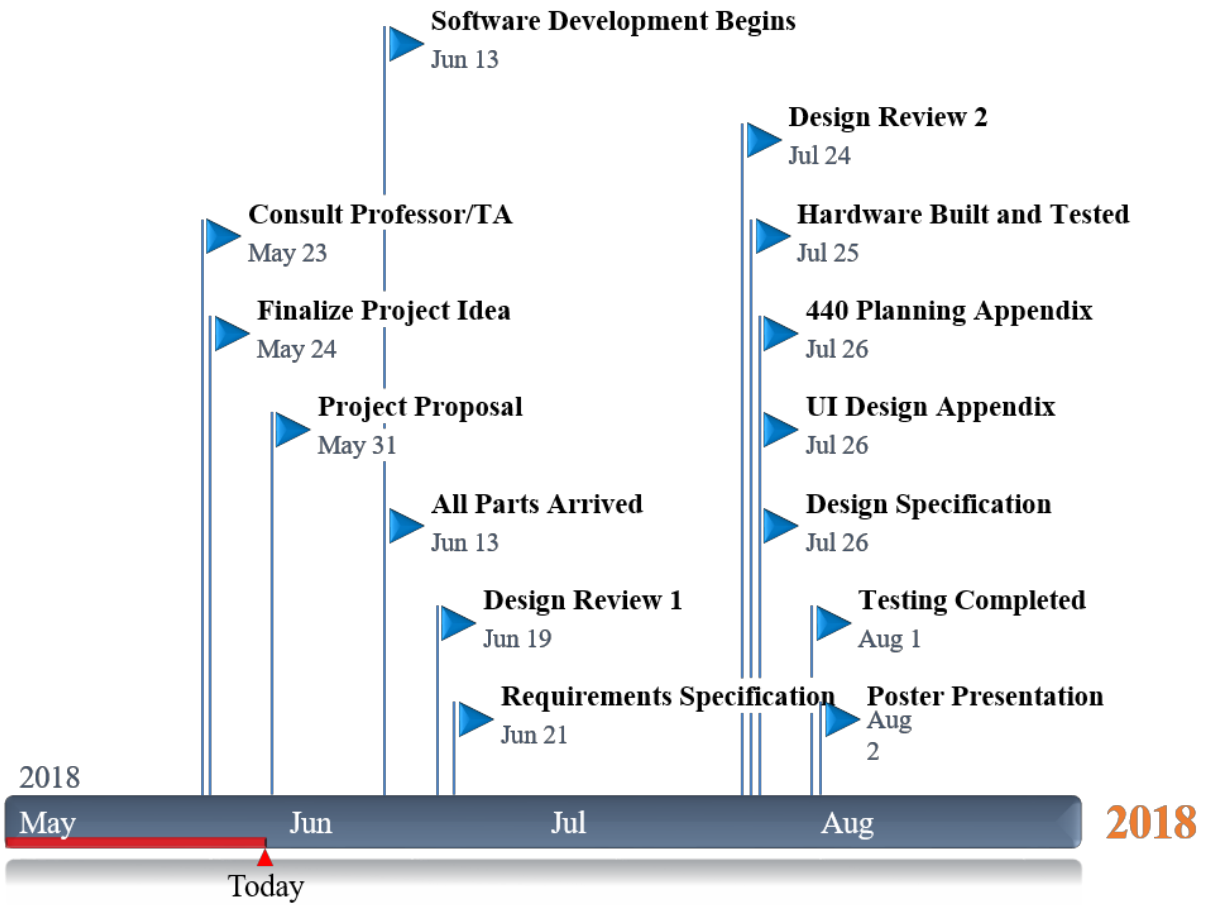


Figure 6.2: Milestones for NuCare Band



## 7. Company Organization

### 7.1 About Us

CardioTech Labs was created with the mission to provide accurate data to doctors and nurses for efficient care and treatment to patients.

The NuCare Band offers a non-intrusive way to monitor cardiovascular patterns which will be logged at the hospital's database as well as allowing caregivers live access to the data.

The band allows the continuous monitoring of patient's condition after hospital discharge, and daily response to treatments.



CardioTech Labs

### 7.2 Our Team



**Alfonso Diaz**  
adiazalo@sfu.ca  
Chief Executive Officer

Alfonso is a fourth year Electronics Engineering student currently doing research at the Communication Networks Laboratory. He is interested on smart DIY projects and machine learning. Having worked a year in Glentel as Co-op on various projects as Network Administrator, he possesses the experience to organise the objective and plan of actions to be followed.



**Carson Lai**  
ckl41@sfu.ca  
Chief Technology Officer

Carson is a fifth-year Computer Engineering student at Simon Fraser University. Having previously worked at Ritchie Bros. Auctioneers, Carson specializes in Information Technology Support. He is keen in all new and upcoming technologies and is quick in adapting and changing to any technological obstacles or challenges he faces.



**Li Teng Cheok**  
lcheok@sfu.ca  
Chief Information Officer

Li Teng is a fifth-year System Engineering student at Simon Fraser University. She has just completed 4 months at PerfectMind as a Quality Assurance Analyst where she took part in testing the accounting aspect of the software. Through various lab experiences and a research co-op term with Rostrum Medical Innovations Inc., she has gained valuable knowledge about troubleshooting and teamwork.



**Qassam Yomok**  
qyomok@sfu.ca  
Chief Product Officer

Qassam is a fourth-year Computer Engineering student at Simon Fraser University. Qassam's primary interests are in machine learning and FPGA design flow. He worked as a software developer at Binary Stream where he developed a software to facilitate firms billing process. During his work, Qassam gained a solid understanding about Agile development cycle and team work.



**Younghoo Jee**  
yjee@sfu.ca  
Chief Operating Officer

Younghoo Jee is a fifth-year Electronic Engineering student at Simon Fraser University. He worked as quality assurance and embedded system developer at T2 systems where he fixed many software test cases using gtest. During his industry work as a co-op student, he has gained knowledge of development workflow and hardware testing.



## 8. Conclusion

Human vital signs are the most fundamental measurements that identify patients' medical problems. Early detection of abnormal vital signs can lead to proper treatment and care during golden hours and further disease prevention. Hence, sophisticated medical wearables can enhance quality of individual's life.

As technology evolves, health care system has shifted its focus from conventional hospital setting to individual centered. This allows medical professions to give more precise and informed diagnosis to patients, followed by appropriate treatments. However, there are huge trade-off for modern medical wearables. The constraints found in current market can be lack of transparency and mobility, poor workflow integration into hospital setting, and, most importantly, expensive cost.

CardioTech Labs is thrilled to propose NuCare Band, that can cater to the needs of the current market. NuCare Band can capitalize on current technology to monitor patients' vital signs routinely and process the data more reliably. It also ensures flawless reliable transmission of patients' data while ensuring their privacy and security. During designing phase, our team will concentrate on the four crucial attributes: accuracy, regulation, security and integration. Moreover, we will aim to design the medical wearable as compact and mobile as possible with efficient energy consumption so that it can be competitive clinical solution. Every team member will endeavor to work on product from designing to implementing throughout ENSC 405W and optimize the prototype more during ENSC 440.



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